EXHIBIT B

Direct-conversion receiver

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In telecommunication, a **direct-conversion receiver** (DCR), also known as **homodyne**, **synchrodyne**, or **zero-IF receiver**, is a radio receiver design that demodulates incoming signals by mixing it with a local oscillator signal synchronized in frequency to the carrier of the wanted signal. The wanted demodulated signal is thus obtained immediately by low-pass filtering the mixer output, without requiring further detection.

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Properties

Unwanted signals are left on carriers of the frequency difference between their original carrier and that of the wanted signal. There is no detection of the unwanted signals since the whole signal path is kept free of non-linearity. Unwanted signals can be completely rejected by use of a low-pass filter on the audio output. The receiver consequently has the advantage of high selectivity, and is inherently a precision demodulator. The principles can be extended to permit separation of signals whose sidebands overlap, and they also lead to improved detection of pulse-modulated signals.

History and applications

The homodyne was developed in 1932 by a team of British scientists searching for a method to surpass the superheterodyne. This new type of receiver was later renamed the synchrodyne, and not only proved to have superior performance, but the single conversion stage also had lower complexity and power consumption. But the circuit after a period of time became unstable due to slight drift in frequency of the local oscillator. To counteract this drift, the frequency of the local oscillator was compared with the input by a phase detector so that a correction voltage would be generated and fed back to the local oscillator, thus keeping it on lock. This type of feedback circuit evolved into what is now known as a *phase-locked loop*. While the method has existed for several decades, it had been difficult to implement due largely to component tolerances, which must be very high for this type of circuit to operate well.

The circuit was not without other problems. Reverse-transmission paths can occur in the receiver. Local-oscillator energy can leak through the mixer to the antenna input and then re-enter the mixer. The overall effect is that the local oscillator energy would self-mix and create a DC offset. The offset could be large enough to swamp the baseband amplifiers and destroy signal reception. There were several work

arounds to deal with this issue but these too added to the complexity of the receiver. Ultimately the higher costs were found to outweigh the benefits.

The widespread use of this principle did not begin until the development of the integrated circuit and incorporation of complete phased-lock loop devices in low-cost IC packages. These are no longer limited to the reception of AM radio, now being able to process more complex modulation schemes. Since then, direct-conversion receivers have been incorporated into many receiver applications, including cellphones, televisions, avionics and medical imaging apparatus.

See also

- Crystal radio receiver
- Directly amplifying receiver
- Reflectional receiver
- Homodyne detection
- Low IF receiver
- Neutrodyne
- Regenerative radio receiver
- Superheterodyne receiver
- Tuned radio frequency receiver

External links

- The History of the Homodyne and Syncrodyne (http://www.thevalvepage.com/radtech/synchro/synchro.htm) *The Journal of the British Institution of Radio Engineers, April 1954*

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